CALIFORNIA DIVISION OF MINES AND GEOLOGY

Fault Evaluation Report FER-76

November 16, 1978

1. Name of fault: Elsinore fault zone (south Riverside County segment) with a description of the Murrieta Hot Springs fault.

2. Location of fault: Wildomar, Murrieta, Bachelor Mtn., Temecula and Pechanga 7.5 minute quadrangles, Riverside County (see figure 1).

3. Reason for evaluation: This fault is located within the 1978 study area of the 10-year program for fault evaluation.

4. List of references:

Davis, W.M., 1927, The rifts of southern California: American Journal of Science, v. 13, p. 57-72.

Earth Research Associates Inc., 1976, Seismicity evaluation and fault activity investigation, area III, Murrieta Hot Springs, California: Unpublished consultants report. (A-P no. C-86, Riverside County Report GR-44).
(Trenches appear to expose Murrieta Springs fault zone but show no certain Holocene displacement.)

Earth Research Associates Inc., 1977a, Fault investigation, tentative parcel map 9095; Rancho California, Riverside County, California: Unpublished consultants report. (A-P no. C-204, Riverside County Report GR-75).

Earth Research Associates Inc., 1977b, Reconnaissance soils engineering, engineering geologic, and percolation investigation, Parcel Map 9259, Riverside County, California: Unpublished consultants report, (A-P no. C-208, Riverside County Report GR-75) proposes a set back but offers no proof of location or activity on the Elsinore fault.

Engel, Rene, 1959, Geology of the Lake Elsinore quadrangle, California: California Division of Mines Bulletin 146, 154 p., map 1:62,500.
(A good case for Quaternary faulting-nothing on Holocene.)

Fairbanks, H.W., 1893, Geology of San Diego County; also of portions of Orange and San Bernardino Counties: California State Mining Bureau, Report 11, p. 76-120.

(Riverside County was not yet created. This area was part of San Diego County.)

Fairchild Air Photos, 1939, C-5750, No.'s 211-27 to 33 and 211-73 to 87, 1:21,800

Jennings, C.W., 1975, Fault map of California with locations of volcanoes, thermal springs and thermal wells: California Division of Mines and Geology Geologica Data Map Series, Map no. 1, scale 1;750,000.

Kennedy, M.P., 1977, Recency and character of faulting along the Elsinore fault zone in southern Riverside County, California: California Division of Mines and Geology Special Report 131, 12 p., map 1:24,000.

("Conclusion: This study documents the previously suspected youthfulness of the Elsinore fault zone in that detailed mapping between Wildomar and upper Wolf Valley indicates that numerous individual faults in the zone displace Holocene sediments. Historic seismicity, though minor, indicates further that this part of the fault zone is presently active.---")

Langenkamp, Davis and Combs, Jim, 1974, Microearthquake study of the Elsinore fault zone, southern California: Seismological Society of America Bulletin, v. 64, no. 1, p. 187-203.

("In comparison to the San Jacinto fault to the east, the Elsinore fault shows a very little strike-slip displacement and is a seismically quiet area except for a localized area of east-west faulting in the far south near Vallecito Mountain.")

Lawson, A.C., and others, 1908, The California earthquake of April 18, 1906, Report of the State Earthquake Investigation Committee: Carnegie Institution of Washington Publications 87, v. 1, part 1 and 2, 451 p.

(The authors include H.W. Fairbanks, probable source for data on the Elsinore fault: see also Fairbanks, 1893.)

Lohr, L.S., 1977a, Fault hazard investigation for P.M. No. 9263 and P.M. No. 9264 Palomar St. and Wesley St., Wildomar area, Riverside County, California: Unpublished consultants report. (A-P no. C-207, Riverside County Report GR-71).

(Evaluates site near Wildomar fault. Trenches did not reveal any faulting.)

Lohr, L.S., 1977b, Fault hazard report for parcel 4 of parcel map no. 6387 as recorded in book 18, page 68 of parcel maps, records of Riverside County lying within the Rancho La Guna: Unpublished consultants report. (A-P no. C-224, Riverside County Report GR-78).

(Note a fault related to the Wildomar which he appears to have projected along strike from a nearby investigation. Probably ok but no trench (see A-P no. C-232, Riverside County Report GR-84).

Lohr, L.S., 1977c, Fault hazards report for parcel map no. 9637 which is a division of government lots 3, 4, 6, 7 and a portion of 2, ofsection 6, T. 7 S., R. 3 W., and government lots 8, 10 and a portion of 1 and 7 of Section 1, T. 7 S., R. 4 W., SBBM: Unpublished consultants report. (A-P no. C-229, Riverside County Report GR-82).

(Two parcels lie athwart a fault that probably is part of the zone of the Wildomar fault. Setbacks are recommended but no trenching was done.)

Lohr, L.S., 1977d, Fault hazards investigation for parcel map no. 9770 a division of a portion of lot 20, block 1 of Elsinore, per book 4, page 174 of maps, records of San Diego County, lying within Riverside County, California; unpublished consultants report. (A-P no. C-232, Riverside County Report GR-84).

(The parcel lies athwart the Wildomar fault which was well exposed in a trench and recorded on a artfully-drawn log. A second fault, probably related to the above, was exposed in another trench. The second fault is overlain by late Quaternary, probably Holocene deposits.)

Lohr, L.S., 1977e, Fault hazard report for lots 3 and 4 of block 33 of the town of Temecula per M.B. 15/726 records of San Diego County, lying within a portion of section 13, T. 8 S., R. 3 W., (projected); unpublished consultants report. (A-P no. C-243, Riverside County Report GR-88).

(Property just south of Temecula. Probably in the zone of the Willard fault but no faulting was reported in two well-placed trenches.)

Lohr, L.S., 1978a, Fault hazard investigation for lots 42, 44, 48, 50 and 52 of block "K" as shown by a map on file in book 4, page 174 of maps, records of San Diego County, lying within Riverside County, California: Unpublished consultants report, (A-P no. C-322, Riverside County Report GR-139.

(The properties lie near mapped traces of the Willard fault. Two trenches cut normal to the fault and at the side of the properties nearest to the fault show no evidence of faulting. However, volcanic rock, possibly the Santa Rosa basalt, was noted on the property. This should be checked out for structural significance. It may greatly affect the amount of displacement on the Willard fault and its location.

Lohr, L.S., 1978b, Fault hazard investigation for property lying on the southerly corner of Guava Street and Washington Avenue, Murrieta, Riverside County, California: Unpublished consultants report.

(Trench shows no faults in an area where we have none - ok.)

Mann, J.F., 1955, Geology of a portion of the Elsinore fault zone California: California Division of Mines and Geology Special Report 43, 22 p., map 1:63, 360. Map shows faulted "Recent" alluvium and author states that, "Minor faulting continued throughout late Pleistocene and recent.

Rand, L. E., 1977, Fault hazard investigation for tentative parcel map no. 9070 the southeasterly 490' of lot 6 block "K" of Elsinore, in the unincorporated County of Riverside County, California: Unpublished consultants report. (A-P no. C-228, Riverside County Report GR-79).

(Parcel appears to lie near the concealed and questioned trace (Weber's map, 1975) of the Willard fault about 1.5 miles northwest of Wildomar. As reported, a trench normal to the fault trend and spanning the full length of the parcel failed to reveal any faulting.)

Real, C.R., Parke, D.L., and Toppozada, T.R., 1977, Magnetic tape catalog of California earthquakes, 1900-1974: Califronia Division of Mines and Geology.

Toppozada, T.R. and others, 1978, Seismicity of California 1900-1931: California Division of Mines and Geology Special Report 135, 39 p.

U.S. Department of Agriculture, 1953, Aerial photos: AXM 1:26000 Black and white.

U.S. Geological Survey, 1975, Aerial photos: GSJ (low sun angle) 1:24,000 Black and white.

U.S. Geological Survey, 1967, Aerial photos: WRD 5D6, 1:12,000. Black and white.

Weber, F.H., Jr., 1977, Seismic hazards related to geologic factors, Elsinore and Chino fault zones, northwestern Riverside County, California: California Division of Mines and Geology Open-File Report OFR 77-4 LA.

Wood, H.O., 1916, California earthquakes: Seismological Society of America Bulletin, v. 6, no. 2, p. 55-180.

Ziony, J.I. and others, 1974, Preliminary map showing recency of faulting in coastal southern California: U.S. Geological Survey Miscellaneous Field Studies Map MF-585, 3 sheets, scale 1:250,000, booklet, 15 p.

5. Summary of available data: Perhaps the earliest description of the Elsinore fault was by Fairbanks (1893), who described features of large-scale faulting in the Temecula-Elsinore area. The first published map to show this fault, and report using the name "Elsinore" was by

Lawson and others (1908, Map no. 1, and p. 19). Wood (1916) listed the historical earthquakes (1769-1907) of California and suggested that a number of the events may have occurred along the Elsinore fault. Davis (1927), discusses the characteristics of the major "rifts" of southern California and makes reference to localities along the north end of the Elsinore fault as examples of various types of features. Mann (1955) mapped the Elsinore fault in the Murrieta - Temecula region. Rene Engel (1959), worked in the Elsinore quadrangle (15 minute) from 1926 to 1933, and was the first to recognize and name most of the individual faults within the Elsinore fault zone. Weber (1977) did a detailed study at, and to the northwest of Lake Elsinore. Work by Kennedy (1977) extended from the south boundary of the work by Weber (just northwest of Wildomar) southeast along the fault to the south boundary of Riverside County. Figures 2a and 2b are a copy of the map by Kennedy (1977) with additions and notations. In describing his investigation Kennedy (1977, p. 8) states: "The faults mapped are those inferred from geomorphic evidence (dashed) and those known to exist from geologic evidence (solid). The geomorphic features noted and considered to have a tectonic or post-tectonic erosional origin were observed on low-sun-angle stereoscopic aerial photographs. These features are linearly aligned, fault-produced topographic features, ponded alluvium, closed depressions, deflected drainages, and faulted spurs. In addition and where occurring with geomorphic evidence of faulting, linearly aligned vegetation and abrupt linear color contrasts considered to be manifestations of a difference in rock and soil type have been used locally as supporting evidence of faulting. Each dashed fault is labeled by an abbreviation that indicates which geomorphic features were used as criteria to suggest faulting. The faults shown by solid lines are based on observations made generally first on aerial photographs but later documented in the field."

The Elsinore fault zone comprises two main traces that flank a narrow and probably complex graben lying beneath the alluviated floor of a linear valley known as the Elsinore trough. The two main traces are the Wildomar fault along the northeast margin of the trough, and the Willard fault along the southwest margin of the trough. Two other faults of lesser extent are associated with the Elsinore fault zone. One is the Wolf Valley fault zone, a group of northwest-striking faults within the south-central part of the trough that may be an eastern ramification of the Willard fault zone. The other fault is the Murrieta Hot Springs fault, which strikes essentially east-west, lies east of the Elsinore fault and is truncated by the Wildomar fault just east of Murrieta (figures 2a and 2b). The segment of the Elsinore fault included in this report is about 33 km long, extending from the Wildomar area, just southeast of Lake Elsinore, southeastward to the Riverside County boundary.

At Murrieta, Mann (1955, plate 2 and p. 17) suggests a minimum vertical displacement on the Willard fault to be 1,027 meters (3,300 feet) and on the same cross section (section B, plate 2) the vertical displacement on the Wildomar fault would be only 60 to 90 meters (200 to 300 feet) less. Mann (1955, p. 21) suggests that most of this displacement took place in the Plio - Pleistocene (the last 3,000,000 $\pm$ years). Using an apparent horizontal separation of a facies boundary in a Pleistocene sandstone-and conglomerate formation, Kennedy (1977, p. 9) suggests more than 5 km (3 miles +) of horizontal offset on the Wildomar fault between Wildomar and Chaney Hill. Although early workers (Mann, 1955; Engel, 1959) drew their fault traces unnaturally straight (as though with a straight edge) the traces on the later, more realistic map of Kennedy (figure 2a) retain a straightness not likely to be achieved by dip-slip displacement alone.

According to Kennedy (p.c., Oct. 1978), two symbols denoting Holocene activity (H) on the Willard fault are drafting errors. These symbols have been changed (figure 2a) to late Pleistocene displacement (L) in accordance with the authors advice. The symbols are tied to two solidly drawn segments of the Willard fault just west and northwest of Wildomar.

Kennedy describes the Willard fault as follows:

> Within this area, the Willard fault zone is composed of a series of northwest-striking, east-dipping, high-angle normal faults. Most individual faults of the zone can be traced for only a kilometer or two and many for less than a few hundred meters. The faults have a complex discontinuous relationship to one another and only as a group form a through-going zone.
>
> In the northernmost part of the area, southwest of Lake Elsinore and directly west of Wildomar, the Willard fault zone is clearly marked by a bold linear topographic expression. This prominent topography persists southwest from Wildomar for approximately 2 km to the mouth of Slaughterhouse Canyon. From this area south to Murrieta, approximately 6 km, the fault zone is mostly obscured by the Holocene alluvium of Slaughterhouse, Cole, and Miller Canyons. Fault-related topography in this area has been obliterated from all but a few locations (plate 1).---
>
> South from Miller Canyon to upper Wolf Valley, linear topography again clearly marks the trace of the fault zone. Small drainage channels are clearly deflected right laterally along this segment of the zone. Faulted Quaternary age sediments and a youthful topographic expression suggest a moderately young age for this part of the zone.

The use of air photos (high-sun-angle WRD; low-sun-angle GSJ) in the Wildomar area led to the discovery of apparent fault traces to the northeast of those mapped by Kennedy in the Wildomar area (figure 2a). The two fault traces designated "L" (late Pleistocene, changed as previously explained) by Kennedy on the willard fault are less distinct than the suggested trace through Wildomar based on linear terrain and one distinct scarp noted by the writer on photos (figure 2a). This suggests that the most recently (probably Holocene) down-dropped block in the center of the Elsinore fault zone is only about .45 km wide at Wildomar and appears much more supportive of Holocene displacement on the Willard fault in that area. The photos show similar features on the projection of this lineament roughly 2.4 km farther southeast, near Murrieta Creek and continuing southeastward to the vicinity of Chaney Hill. This bypasses Kennedy's anomalous absence of fault-derived features across the fan at the mouth of Slaughterhouse Canyon west of Chaney Hill.

At Murrieta, some 4 km farther southeast, the valley floor widens. If any scarps once existed along the suggested traces of the Willard fault immediately southwest of that community they might have been reduced by cultivation and grazing. So, the projection of apparent fault traces southeast from the Chaney Hill area is at best uncertain.

As drawn by Kennedy (figure 2a), from Murrieta southeast to the County boundary the main trace of the Willard fault lies at or just above the base of the northeast slope of the Santa Ana Mountains.

The numerous water courses that cross this segment of the fault show no consistant offset right or left lateral. Kennedy shows no evidence of Holocene displacement.

The Wolf Valley fault (near the right margin of figure 2a) is shown as mapped by Kennedy who states:

> The Wolf Valley fault zone appears to branch east from the Willard fault zone, 2-3 km southeast of Temecula, though this questionable relationship is masked by the modern alluvium that has issued from several northeast-flowing tributaries that feed Pechanga Creek along the southern side of Wolf Valley.

The trace as mapped by Kennedy is a distinct linear feature on air photos. He states:

> West of the Wildomar fault zone, in the central part of Wolf Valley, Holocene alluvium is offset by a series of mostly north-west-striking *en echelon* faults that constitute the Wolf Valley fault zone.

Here then, as in the Wildomar-Chaney Hill area, evidence of Holocene displacement appears to lie on the valley floor northeast of the main trace of the Willard fault.

Kennedy (1977, p. 9) describes the Wildomar fault as follows:

> Between Lake Elsinore and Chaney Hill (latitude 33° 34' 47" N., longitude 117° 14' 23" W.), small sag ponds, faceted spurs, and lateral deflected stream channels clearly mark the most recent breaks of the Wildomar fault zone.----
>
> South from Chaney Hill to the town of Murrieta, the Wildomar fault zone is less sharply defined by strong physiographic expression. This segment of the zone is underlain by, and displaces, older alluvial deposits of the late Pleistocene age Pauba Formation.

> Between Murrieta and Interstate Highway 15, little evidence exists for the location of the fault. A ground-water barrier coincident with the zone through this area (Moreland, 1972) exists in Quaternary alluvial deposits of Murrieta Creek. The water table is displaced downward along this part of the zone on an average of 10 m to the west.
>
> South from Interstate Highway 15 to upper Wolf Valley in Rancho California, a strongly linear erosion scarp marks a recent trace of the Wildomar fault zone. The width of the fault zone is uncertain through this area because the lowlands west of the prominent eastern scarp, in Pauba and Wolf Valleys, are underlain by apparently unfaulted modern alluvium that has been cultivated in recent years.

The most convincing evidence of Holocene displacement on the Wildomar fault is found in the vicinity of the community of Wildomar (included in first quote above). The map (figure 2a) shows three closed depressions (cd). The most southern of these lies on a mapped fault trace, at the foot of an obvious scarp. Both scarp and closed basin (sag pond) are clearly discernible on air photos. Very near the southeast end of the basin a trench was dug in the course of an engineering geologic investigation (figure 3, trench "C"). The log of that trench shows a fault displacing Holocene soil. Another trench (trench "B", figure 3) cut the scarp northeast of the closed basin (labeled "sump" on figure 3). This trench revealed a fault and what appears to be a buried fault scarp, as drawn on the log of trench "B" (figure 3). The log suggests the unlikely proposition that the scarp was covered by fluvially transported material without being eroded. It is most probable that the uppermost lithologic unit, upon which the present surface has developed, was cut by fault displacement there by preserving the linear, though now subdued, nature of the scarp. The fault break(s) in the youngest (probably Holocene) unit might have been degraded by burrowing animals, roots, and weathering.

The Murrieta Hot Springs fault (figure 2b) is described in considerable detail by Kennedy (1977, p. 10). In summary:

(1) It intersects and is either cut off by, or is an eastern branch of, the Wildomar fault zone at Murrieta.

(2) Though partly obscured by Holocene soils and alluvium the fault can easily be traced from Murrieta to Buck Mesa, a distance of about 15 km.

(3) As yet, no site has been found where the Murrieta Hot Springs fault displaces Holocene sediments.

One topographic feature, Skunk Hollow (center of east half of figure 2b), suggests that vertical displacement on or near this fault has exceeded the rate of erosion or has been too recent for adjustment to have taken place.

Several shallow trenches dug across the trace of the Murrieta Hot Springs fault (marked in red on figure 2b) exposed faulting and fracturing in Pleistocene sediments (Earth Research Associates Inc., 1976, plates D,E, and F).

6. Interpretation of air photos: With the aid of U.S. Geological Survey Water Resources Development photos (1967), ~~and~~ U.S. Geological Survey low-sun-angle (GSJ) photos (1975), US Department of Agriculture (AXM) photos (1953), and Fairchild (ANX) photos (1939) many of the features used by Kennedy (1977) to trace and describe faults in the Elsinore fault zone were confirmed and a few were added (figures 2a and b). Further use of these photos will be made during field checking.

7. Field observations: Several localities along the south Riverside County segment of the Elsinore fault were visited on November 7, 1978. The site localities are described below, the numbers corresponding to map figure 2a.

Locality S1. The lowest terrace surface of Long Canyon and the soil unit developed on it are distinctly warped downward toward the southwest being completely buried by the modern alluvium of the drainage in that direction. The apparent structural deformation of the terrace surface is of probable Holocene occurrence based on the very late Quaternary age of the terrace and the time required to develop a thick uniform soil on the terrace deposit. Warping is most likely due to normal faulting to the southwest along a concealed fault at the base of the low hills (about 200 feet west of the trace identified as "L" by Kennedy). Aligned with this is the deflected drainage of the next stream to the south. Half a mile to the northwest, a zone of tensional faults is exposed in a gully cut 100-200 northeast of the base of the steep hill front in Pauba Formation beds of late Pleistocene age. To the northeast, the Pauba beds are nearly horizontal, but steepen abruptly across the fault (to the southwest) to 40-50° SW. The slightly closed depression and ponded water just southwest of the hill front suggests recent deformation and a shallow ground water barrier. Collectively, the data strongly indicate very late Quaternary faulting and associated deformation along the base of the hills.

Locality S2. A strand of the Wildomar fault zone is exposed on the east banks of a flood control channel. This fault aligns with faceted spurs to the northeast and coincides with the trace of the Wildomar fault as shown by Kennedy (1977).

Locality S3. Road cut on the northwest side of road in low hill exposes minor faults in Pauba Formation. Some of the faults extend upward into the soil unit, which is apparently offset and sheared. Offset is apparently down to the southwest on the southwest side of the low hill and down to the northeast on the northeast side of the hill cut.

Locality S4. An artificial cut at the top of a low knoll exposes beds of the Pauba Formation of Kennedy apparently in fault contact with an older soil unit (east side down). There is no evidence of a recent scarp at the ground surface, indicating that faulting is pre-Holocene. This fault lies along the Wolf Valley fault zone of Kennedy.

8. Seismicity: Since 1900 only one earthquake within the magnitude range of 0 to 6.9 has been plotted (with an accuracy of 2 to 3 km) on the Elsinore fault zone in the area of this report. That quake had a magnitude of 3.1 and a hypocentral depth of 8 km. It occurred in the Wildomar area (Real and others, 1978). A microearthquake study was made by Langenkamp and Combs (1974) along the Elsinore fault zone between Corona and the Mexican border. They found an increase in frequency and depth to the southeast. The CDMG Catalog (Real and others, 1978) shows a marked increase in activity to the northwest. So, the area of this report may be "hung up" and subject to infrequent but fairly large magnitude earthquakes.

9. Conclusions: Evidence of Holocene faulting indicates that the Wildomar fault is the most active strand of the Elsinore fault zone (south Riverside County segment). Holocene activity is best documented near Wildomar and at Locality S2 (figure 2a). The Wildomar fault is fairly well-defined over most of its length, although is may consist of several strands locally. The sense of displacement apparently is both normal (up on the northeast) and right-lateral strike-slip. By comparison, the Willard fault of Kennedy is poorly-defined and nowhere has it been exposed. Its position is inferred from subtle topographic features that can be explained by processes other than Holocene faulting. Firm conclusions cannot be drawn about the Wolf Valley fault. However, based on brief field reconnaissance (11/7/78), some of its strands (shown by Kennedy) do not appear to offset Pleistocene fan surfaces or drainages that cross the traces. Also, the principal strand of Kennedy, apparently based on a northeast facing topographic escarpment, may be the result of erosion instead of recent faulting.

10. Recommendations: There is good evidence that most of the Wildomar fault is sufficiently active and well-defined to warrant zoning under the Alquist-Priolo Special Studies Zones Act. However, such evidence is not documented for the Willard, Wolf Valley and other faults of the Elsinore fault zone in the evaluated area. It is recommended that additional field checking and photo interpretation be conducted to determine more specifically which fault strands should be zoned and which ones excluded.

11. Investigation by:

RICHARD B. SAUL
11/16/78

Richard B Saul

I concur with the recommendations.
EWH
11/29/78

Figure 1 FER-76
Index of topographic maps involved in this report.

MISCELLANEOUS FIELD STUDIES
MAP MF- 585
SHEET 3 OF 3